METHOD AND APPARATUS FOR CONDITIONING COINS PRIOR TO DISCRIMINATION

The present application is a continuation of Serial No. 08/807,340, filed February 28, 1997 and claims priority in U.S. provisional application Serial No. 60/012,964, filed March 7, 1996 for **METHOD AND APPARATUS FOR CONDITIONING COINS PRIOR TO TRANSPORT, SORTING AND COUNTING,** ~~commonly assigned herewith and both incorporated herein by reference.~~

This invention relates to a device and method for conditioning coins and in particular for removing debris, contamination, corrosion and unwanted materials from coins prior to transport to devices for automatically counting and/or sorting the coins.

BACKGROUND INFORMATION

Coin counting and sorting equipment is often adversely affected by the presence of foreign matter. Mechanical and electronic sorting systems and methods can fail, be damaged, caused to misread and/or become jammed. Mechanical devices such as coin transport mechanisms, coin hoppers and the like may be caused to jam or otherwise malfunction by foreign matter. Sensors may be prevented from accurately identifying a coin because of non-coin matter accompanying the coins. Sensors may become blocked or rendered ineffective because of non-coin matter collecting and or being deposited onto sensor parts. When the sensors fail the coin counting process has failed and coins are often undesirably rejected or are accepted as the incorrect denomination. The amount of non-coin matter varies and is unpredictable. In many situations, the reliability and accuracy of coin sorting, identification and/or counting processes is very important and thus the process of removing non-coin matter before the coins are transported to sorting, identification and/or counting sensors is important. The presence of non-coin matter is believed to be especially troublesome in the context of self-service, stand-alone, unmonitored and/or unattended devices, e.g. devices for counting/sorting coins by the general public or other non-trained persons. Accordingly, it would be useful to provide self-service coin processing machinery which can process coins which are accompanied by non-coin matter.

The removal of one type of undesirable non-coin matter does not often eliminate other kinds because the material is so varied. Metal objects may be identified by properties such as density, shape, magnetic characteristics, etc. Typically, removing dense matter such as rocks is entirely different than removing metal or paper objects. Coins may have been stored with materials that have caused corrosion or have become coated with oils, glue and other liquids that collect dirt and other debris. These coins contaminate others as they come into physical contact and may cause adhesion, clumping or grouping of coins. A magnetic separator would not eliminate all this various non-coin matter.

SUMMARY OF THE INVENTION

The present invention provides for separating non-coin objects from coins in a coin-sorting, discriminating or counting device, preferably prior to coins reaching certain coin transport devices, such as transport devices for transporting coins toward a hopper or sensor, preferably prior to coins reaching a coin hopper which provides coins to sensors and preferably prior to the coins reaching the counter/sorting sensors. In one embodiment the separation device is a generally tubular or concave surface, having one or more openings through which non-coin objects travel, and which cause coins introduced thereto to undergo relative movement to assist in separation of non-coin objects. In one embodiment, the relative movement preferably involves lifting some coins with respect to others and may be achieved by pivoting or rotating the tubular or concave surface, e.g., about an axis. Agitation may be further enhanced by projections formed in or attached to the surface, such as vanes, fins, blades, spines, dimples, ridges, and the like. Movement of coins through or across the tubular or concave surface may be effected or enhanced by various mechanisms. Although gravity feed may be used, in one embodiment blades such as angled, spiral or helical blades assist in moving the coins e.g. in a screw conveyor fashion.

Except for coin entrance and exit ports, diameters, sizes or shapes of the openings are configured to prevent passage therethrough of the smallest coin intended to be counted by the counting device. In one embodiment, a drive mechanism rotates the cylinder about its longitudinal axis to agitate the coins therein by lifting coins and, preferably, moving the coins through the cylinder by a screw mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a coin-counting device of a type which may be configured to incorporate features of the present invention;

Fig. 2 is a rear perspective view of a receiving tray and rib slide of a type which may be provided in the apparatus of Fig. 1;

Fig. 3 is a schematic side view of a feed tray and tumbler device according to an embodiment of the present invention;

Fig. 4 is a schematic depiction of the position of a helical blade in an embodiment of the present invention;

Fig. 5 is a partial side view of a tumbler device according to an embodiment of the present invention;

Fig. 6 is an end view of a tumbler device according to an embodiment of the present invention;

Fig. 7 is a partial perspective view, partially exploded, of a tumbler device according to an embodiment of the present invention;

Fig. 8 is a partial perspective view, partially exploded, of a tumbler device according to an embodiment of the present invention;

3

Fig. 9 is a rear perspective view of a modular feed tray/tumbler device according to an embodiment of the esent invention, which may be incorporated into the apparatus of Fig. 1;

Fig. 10 is a side view of the apparatus of Fig. 9;

Fig. 11 is an end perspective view of the apparatus of Fig. 9;

Fig. 12 is an end view of a tumbler cylinder, according to an embodiment of the present invention;

Fig. 13 is a front perspective view, with exploded cover plate, of an apparatus according to an embodiment of the present invention;

Fig. 14 is a front perspective view, partially exploded, of the apparatus of Fig. 13;

Fig. 15 is a rear perspective view, partially exploded, of the apparatus of Fig. 13;

Fig. 16 is a perspective view, partially exploded, of a trommel assembly, according to an embodiment of the present invention;

Fig. 17 is a perspective view of a first end cap which may be used in connection with an embodiment of the present invention;

Fig. 18 is a perspective view of a trommel body, according to an embodiment of the present invention;

Fig. 19A - D are right side elevational, top plan, left side elevational and end views of a trommel body in open configuration, according to an embodiment of the present invention;

Fig. 19E is a side view of a vane which may be used in connection with an embodiment of the present invention;

Fig. 20 is a perspective view of a long object trap of a type which may be used in connection with an embodiment of the present invention; and

Fig. 21 is a cross sectional view taken along line 21 - 21 of the device of Fig. 20.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 depicts a coin-counting device which may incorporate features of the present invention. Fig. 1 depicts a device in perspective with various doors opened, and a bag trolley 1610a partially withdrawn. In the embodiment of Fig. 1 a coin tray 1402 is mounted pivotally about axis 1414 (Fig. 2), so that a user, after inserting coins in the tray 1402 may lift the tray, using handle 1404, to move coins out of the tray area 1424, over the ridge or peak 1414, and onto a slope 1428, for movement past a gate 1432, and onto a ribbed chute 1406. Coins are moved into a hopper 1604 for transfer to a counter or sorter 1212, where sorted or counted coins are diverted to bins or, in the embodiment of Fig. 1, bags 1608 held in the trolley 1610a, 1610b. Information processing and/or communication devices and/or printers or dispensers 1628, 1874, which may include, e.g., a computer and/or printer may be provided for outputting information about the sorted coins or counted coins, as described, for example, in PCT application PCT/US95/05356 filed May 1, 1995, and/or U.S. application 08/255,539 filed June 6, 1994, both of which are incorporated herein by reference.

Although the invention is described herein in the context of a device for discriminating or handling coins, the device can generally be applied to separating small, typically unwanted matter or material from larger items. For purposes of the following discussion, the smaller separated items or material (which can include e.g., without limitation, dust, sand, lint, paper, hair, liquids, and myriad other items) will be referred to from time to time herein generically as "dirt" with the understanding that many types of small items or materials, some of them valuable items or materials, can be separated using the present invention.

While the device of Fig. 2 has proved to be useful and can assist, to at least some degree, in removing non-coin matter from a batch or plurality of coins deposited in the tray 1402, e.g., through perforations therein and/or traveling over the chute 1406 (e.g., by perforations therein). It is believed additional improvements in preparing coins for counting/sorting can be achieved by incorporating a device which lifts or otherwise moves coins, relative to one another, to assist in separating non-coin matter.

In general, Figs. 3 through 12 and Figs. 13 through 21 illustrate different embodiments of the present invention, with the understanding that the illustrated embodiments are not necessarily either mutually exclusive (since features or aspects of one embodiment might be incorporated or substituted into another embodiment), nor incompatible (in the sense that some features or aspects of the invention may be common to more than one embodiment).

In the embodiment depicted in Fig. 13, a device is illustrated which may be generally considered in four sections: an input tray section 1302, a trommel feed section 1304, a trommel section 1306, and trommel output section 1308. The illustrated input tray section 1302 is substantially similar to that described in U.S. Patent Serial No. 08/255,539 (now U.S. Patent 5,564,546) and/or PCT/US95/05356, and as described briefly above. The trommel feed region 1304 contains, in the illustrated embodiment, a first chute 1310, and a second chute 1312 for conveying coins and other materials to an input opening of the trommel (described below). The trommel feed region 1304 may contain devices for performing additional functions such as stops or traps, e.g., for dealing with various types of elongate objects, a gate for controlling flow of coins and other objects, lights or other signaling devices, e.g., for prompting input of coins or cessation thereof, and/or drive devices or transmissions for rotating or otherwise moving the trommel as described below. The trommel region 1306 contains a perforated-wall trommel 1314 rotatably mounted via end caps 1316, 1318, which preferably contain bearing surfaces. The trommel output region 1308 provides an output chute for directing the (at least partially) cleaned coins exiting the trommel in a desired direction 1320, e.g., towards a hopper 1604 or similar device.

As best seen in Fig. 15, the first chute 1310 may be provided with first and second pins 1322a, 1322b. The pins 1322a, 1322b are provided to block passage of elongate flexible items such as lottery tickets, cardboard, paper and the like. The spacing between the pins 1322a, 1322b or between the pins and the sides of the chute 1310, determines the size of the largest item which may be allowed to pass. In one embodiment, the pins are positioned to allow a coin with a diameter of about 34 mm to pass, but to block items larger than about 34 mm. In one embodiment, the tray 1310

is stainless steel and the pins 1322a, 1322b are steel pins welded to the chute 1310. Although two pins are depicted, more or fewer pins could be provided, it being understood, however, that pins tend to slow down coin feed rates somewhat. In the depicted embodiment, the pins 1322a, 1322b are about two inches (about 5 cm) apart, disposed symmetrically of the center line of the first chute 1310. In the depicted embodiment, the pins are about 0.5 inch (about 12 mm) high.

A controllable gate 1324 is mounted transverse to the first chute 1310 to permit rotation from the closed configuration depicted in Fig. 15, blocking passage of coins, to an open configuration permitting passage of coins or other objects past the gate. Preferably the gate 1324 is formed of rubber, e.g. to avoid pinching of fingers. Rotation of the gate 1324 is controlled by a solenoid 1326. The solenoid 1325 is activated in response to a signal from a control device such as a computer or other information processing device 1628, 1874 (Fig. 1). The gate may be controlled to open or close for a number of purposes, such as in response to sensing of a jam, sensing of load in the trommel or hopper, and the like. In the depicted embodiment, signal devices such as LED or other lights 1328a, 1328b, can provide a user with an indication of whether the gate 1324 is open or closed (or otherwise to prompt the user to feed or discontinue feeding coins or other objects). Although instructions to feed or discontinue may be provided on the computer screen (Fig. 1), indicator lights 1328 are believed useful since users often are watching the throat of the chute 1310, rather than the computer screen, during the feeding of coins or other objects.

Downstream of the first chute 1310 and gate 1324 is a second chute assembly 1312. Preferably, the second chute 1312 provides a funneling effect by having a greater width 1330 at its upstream edge than its downstream edge. Preferably, the coins cascade or "waterfall" when passing from the first chute 1310 to the second chute 1312, e.g. to increase momentum and tumbling of the coins. In one embodiment the width at the upstream edge is about 5.2 inches (about 13 cm), and the width at the downstream edge is about 2.5 inches (about 6 cm). Preferably, the depth of the chute increases in the directional flow, such as providing a depth of about one inch (about 2.5 cm) at the upstream edge, and a depth of about 1.5 inches (about 3.8 cm) at the downstream edge.

Preferably, the chute 1312 is configured to facilitate coin travel, e.g., by reducing or eliminating the effects of friction, surface tension, and the like. Preferably, the chute 1312 upper surface has no flat region large enough for a coin to contact the surface over one of the faces of the coin, i.e., preferably the coin which touches the chute 1312 preferably makes contact on, at most, two points. Preferably, the surface of the chute 1312 is constructed such that it has a finite radius of curvature along any plane normal to its longitudinal axis 1332, and preferably with such radii of curvature increasing in the direction of coin flow.

Preferably the chute 1312 has an upper surface which is substantially smooth and free from protrusions, ridges, throughholes or other holes, and the like. In one embodiment the chute 1312 is formed from injected molded plastic such as an acetal resin or plastic, a polyamide polymer, such as a nylon, Delrin®, available from E.I.. DuPont de

Nemours & Co., and the like. Other materials that can be used for the chute include metals, ceramics, fiberglass, reinforced materials, epoxies, ceramic-coated or -reinforced materials and the like.

As best seen in Fig. 14, the trough assembly 1312 terminates in a collar 1333 defining a mouth 1334, which is configured to feed coins from the chute 1312 into a first opening 1336 of the trommel assembly 1338. The mouth 1334 is formed with an upper lip 1340. In the depicted embodiment the first opening 1336 of the trommel assembly 1338 is defined by a first end cap 1316 which is coupled to a trommel body 1314. The first end cap 1316 has a smooth cylindrical bearing surface 1342 configured to mate with a bearing surface 1344 of the chute collar, supporting the rotation of the trommel assembly 1338 about a rotation axis 1346 in a manner described more fully below. An exterior surface of the first end cap 1316 is geared 1348 to mesh with a drive gear 1350 powered by a drive motor 1352. The drive gear 1350 is preferably spaced from the stationary bearing 1344 sufficiently to permit manual engagement of the end cap gear 1348 with the drive gear 1350 and simultaneous mating of the first end cap bearing 1342 with the stationary bearing 1340 by merely grasping the trommel assembly 1338, aligning it with the collar 1333 (preferably facilitated by a bevel), rotating the trommel assembly 1338 about its longitudinal axis as needed to mesh the gears 1348, 1350, and pushing towards the chute collar 1333. Similarly, the trommel assembly 1338 may be manually disengaged from the drive gear 1350 and bearing 1344 by pulling in a direction away from the chute collar 1333. Preferably, as best seen in Figs. 16 and 17, the end cap 1316 includes resilient tabs 1712a, 1712b, 1712c, 1712d for engaging slots 1812a, 1812b, 1812c, 1812d, respectively, and tabs 1714a, 1714b, 1714c, 1714d for capturing corners of the trommel 1314.

A similar system of tabs 1612a, 1612b, 1612c, 1612d, 1614a, 1614b, 1614c, 1614d engage and capture slots 1814a, 1814b, 1814c, 1814d, and corners of the downstream end of the trommel 1314. Preferably, the tab and slot system 1712a, 1712b, 1712c, 1712d, 1812a, 1812b, 1812c, 1812d, or the trommel 1314 and first end cap 1316 are different from the tabs 1612a, 1612b, 1612c, 1612d, 1814a, 1814b, 1814c, 1814d of the second end cap 1318 in such a manner that the end caps 1316, 1318 are coupled to the first and second ends 1616a, 1616b of the trommel 1314, respectively, and not the other way around. In the depicted embodiment, the downstream tabs and slots have dual protrusions and openings corresponding to the single protrusions and openings of the upstream tabs and slots. Preferably, the resiliency of the tabs 1712A, -B, -C, -D, 1612A. -B, -C, -D is such that the end caps 1316, 1318 remain securely coupled to the trommel 1314 during normal use, but may be manually removed without the use of special tools, preferably without the use of any tools, e.g., for cleaning, as described below. Preferably, the end caps 1316, 1318 are formed of a plastic material such as an acetal plastic, nylon, Delrin® and the like. Preferably, when both the end caps 1316, 1318 and the bearing surfaces 1344, 1360 are formed of plastic, different plastics are used for mating bearing surfaces, such as by forming the end caps 1316, 1318 of Delrin® and the bearing surfaces 1344, 1360 of a nylon. This is believed to reduce friction and facilitate rotation of the trommel.

As best seen in Fig. 18, the trommel 1314 is shaped to define four rectangular walls 1816a, 1816b, 1816c, 1816d to define a substantially square cross section. In the view of Fig. 18, interior vanes have been removed, for clarity. The trommel 1314 provides at least one hole for permitting passage or exit of dirt from the trommel and, preferably, as depicted, includes a plurality of such holes 1818. The holes 1818 are sufficiently small to prevent passage of the smallest coins (or other object to be discriminated). In one embodiment, when the device is used in connection with U.S. coins, the holes 1818 have a diameter of about 0.61 inches (about 1.5 mm) to prevent passage of U.S. dimes. In the depicted embodiment, the holes have an inter-row and inter-column spacing 1916a, 1916b of about 0.7 inches (about 18 mm). The number, density and distribution of holes 1818 can be configured in a number of ways, other than that depicted. Many factors affect the choice of the number, size, density and distribution of holes. For example, the configuration of the holes affects the overall strength and stability of the trommel 1314 and thus the configuration of the holes may be modified to accommodate the characteristics of different materials used for forming the trommel 1314. The configuration depicted in Fig. 18 is generally believed to provide a relatively large, total hole area (to facilitate removal of dirt) while maintaining the desired structural integrity and sturdiness of the trommel 1314. The depicted distribution of holes in rows and columns is believed to contribute to stability, although other configurations are also possible, such as hexagonally-centered holes, randomly positioned holes, and the like. Although in the configuration of Fig. 18 all the holes are of the same size, it is possible to provide holes in various sizes (smaller than the largest hole which prevents passage of the smallest coin to be treated). Although it is preferred to distribute holes 1818 over substantially the entire inner surface of the trommel 1314, it would be possible, if desired, to position holes such that some areas of the trommel are substantially free from holes.

In the depicted embodiment dimples 18 are formed protruding slightly into the interior region of the trommel 1313. The dimples 1820 are believed to facilitate throughput by avoiding adhesion (such as surface tension - induced adhesion) and/or friction between coins and the interior surface of the trommel. The dimples are believed to reduce the likelihood of adhering a customer's coins to the trommel wall, resulting in loss of credit to the customer. It is believed the dimples prevent or reduce surface-to-surface contact of coins with an interior surface of the trommel over a substantial region of the coin face surface and, accordingly, in the depicted embodiment, dimples 1820 are positioned in any location of the interior surface where a flat region of substantial area would otherwise occur (such as regions between holes). Other shapes, sizes, locations and distributions of protrusions, ridges, fingers, and the like may also be useful to facilitate throughput.

A configuration of a trommel according to one embodiment of the invention is illustrated in Figs. 19A through 19D. In the depicted embodiment, the trommel is formed from two halves 1902a, 1902b, rotationally coupled, e.g. by a hinge, such as a piano hinge 1904 or other rotational device such as clips, screws, interconnecting tabs and slots, and the like. The hinge 1904 permits the two halves 1902a, 1902b to be reconfigured in a "clam shell" fashion between the closed operating configuration depicted in Fig. 18, and an open configuration (e.g., for maintenance) depicted in

Figs. 19A through 19D. The edges 1906a,. 1906b diagonally opposed to the hinge 1904 are fitted with latching devices such as tabs 1908a, 1908b, 1908c, 1908d, which resiliently latch, in an interference fashion, with corresponding regions 1910a, 1910b, 1910c, 1910d of opposing edges. The end caps 1316, 1318 further assist in maintaining the trommel in the closed configuration during operation.

The dimensions of the trommel may be selected depending upon the desired capacity and throughput, as well as the structural requirements for the trommel. In the depicted embodiment, the trommel has a length 1912 of about 10.6 inches (about 27 cm), with each wall having an effective width 1914 of about 2.9 inches (about 7.5 cm).

In general, it is preferred to provide a trommel which causes or at least urges coins, during rotation of the trommel, to freely fall through at least a portion of the interior of the trommel (as opposed to, for example, merely rolling or tumbling in a mass adjacent the lowest surface of the trommel. Thus, preferably the trommel assists in lifting coins, as it rotates, and dropping the coins from an elevated height through at least a portion of the interior of the trommel. Without wishing to be bound by any theory, a number of features of the trommel are believed to contribute to the desired coin lifting/free-fall. It has been found, for example, that a trommel with a circular cross-section tends to result in coins remaining adjacent the lower surface (albeit while tumbling), without substantial lifting or free-fall. It is believed that providing a trommel cross-section which defines flat surfaces and/or corners (i.e., surfaces meeting at an angle) assists in coin lifting/free-fall. In the depicted embodiment, the trommel has a substantially square cross-section, thus defining four substantially flat surfaces, and four corners. It is believed that other cross-sections may provide at least some desirable lifting/free-fall, including cross-section which have corners but no flat surfaces, and/or cross-section with more or fewer than four flat surfaces. Cross-sections which are non-regular (such as isosceles triangular cross-sections) or which have local concavities, such as star-shaped cross-sections, may be useful in some contexts. Other potential cross-sections include triangles, pentagons, hexagons, octagons, semi-circles, rectangles, inflated or pillowed cross-sectional shapes (such as defined by three or more intersecting circular or elliptical arcs), cross-sections with surfaces defined by various non-linear shapes such as ellipses, parabolas, hyperbolas, and the like. Although the depicted embodiment provides a trommel which has a cross-section that is substantially constant along its longitudinal axis, it is also possible to provide trommels with cross-sections that vary along the longitudinal axis such as tapering or flaring cross-sections. Although a number of trommel configurations are operable and each may provide certain advantages in some circumstances, the depicted configuration is believed to provide at least the advantages of relatively low manufactured cost, easy access, low parts count, wider material choice and ease of design, construction, and maintenance.

Another feature which is believed to contribute to the desired lifting/free-fall behavior of the coins or other objects is a provision of one or more vanes protruding into the interior of the trommel 1922a, 1922b, 1922c, 1922d, 1924a, 1924b, 1924c, 1926a, 1926b, 1926c, 1926d, 1928a, 1928b, 1928c, 1928d. It is believed that by positioning vanes at an angle such as about 15° 1930 to a plane passing through the longitudinal axis 1932, the vanes assist not only

8

in providing coin-lifting/free-fall, but also assist in moving the coins in a direction towards the output region 1308. Although it would be possible to provide one or more vanes whose lateral position (with respect an interior surface of the trommel) changed monotonically, it is believed such configuration is not as effective in assisting with movement of coins towards the output portion 1308, as a configuration in which the lateral position of the vane changes non-monotonically. In the depicted embodiment this is accomplished by providing the vanes in several subparts or segments, defining discontinuities or nodes at longitudinal positions 1936a, 1936b, 1936c, 1938a, 1938b, 1940a, 1940b, 1940c, 1940d, 1942a, 1942b, 1942c therebetween. Without wishing to be bound by any theory, it is believed that a configuration in which the nodes for adjacent sides of the trommel are at similar longitudinal positions does not promote the desired transport of coins towards the output end 1308. Accordingly, the nodes 1936a, 1935b, 1936c, 1938a, 1938b, 1940a, 1940b, 1940c, 1942a, 1942b, 1942c, are preferably configured such that nodes defined on one surface are at longitudinal positions different from the node positions for an adjacent surface and, preferably, different from node positions for all other surfaces, as depicted. In the depicted embodiment, eleven of the fifteen vane segments are the same length (about 2.7 inches or about 6.8 cm in the depicted embodiment), with the desired node offset resulting in the remaining segments 1922a, 1922d, 1926a, 1928d being shorter.

In the depicted embodiment, vanes are separately formed and attached to the interior surfaces of the trommel. Preferably, attachment is via tabs (not shown) protruding from the undersurface of the vanes and engaging with slots (not shown) formed in the trommel surfaces. In the depicted embodiment, rivets 1948 are used for attachment. Attachment could also be by interference fit, bolts and nuts, welding, brazing, soldering, adhesives, or vanes may be integrally formed with the trommel. In one embodiment the vanes are formed of a material similar to the material used to form the trommel surfaces, preferably stainless steel, although plastics, fiberglass, ceramics, and the like can also be used.

In one embodiment, as depicted in Fig. 19E, the vanes protrude a distance 1952 into the interior of the trommel of about 0.45 inches (about 1.2 cm). In the depicted embodiment, the upper portion (such as the upper 0.2 inches (about 5 mm) 1954 is angled (e.g., at about 45°) 1956 to a normal 1958 to the adjacent trommel surface. The angled portion 1954 is believed to assist in lifting the coins higher (compared to non-angled vanes) during trommel rotation..

In the depicted embodiment use of vanes for assistance in moving the coins towards the output in 1308 is particularly useful since the depicted configuration shows a substantially horizontal longitudinal axis 1346. If desired, a device can be constructed such that the rotation axis 1346 departs from the horizontal, such as being inclined towards the output end 1308, e.g., to assist in movement of coins towards the output portion 1308. The inclination, or lack thereof, of the rotation axis 1346 is determined by the location of the downstream bearing 1360 which engages the cylindrical bearing surface 1362 of the second end cap 1318. Preferably, the bearing ring 1360 is formed of a plastic material such as a nylon or Delrin®, and is preferably formed of a material different from the material of the bearing

4

surface 1362 of the second end cap 1318. The second end cap 1318 defines an opening 1364 through which coins or other objects exit from the trommel assembly 1338.

The output bearing 1360 is held in position by an end wall 1366. In the depicted embodiment, the end wall 1366 is mounted to the frame 1368 so as to permit the end wall 1366 to be moved so as to allow the trommel assembly 1338 to be withdrawn 1368, e.g., for cleaning or maintenance. In the depicted embodiment, the end wall 1366 is coupled to legs 1372a, 1372b which fit into rails 1374a, 1374b, 1374c, 1374d, to permit sliding movement in an engagement direction 1376a or disengagement 1376b direction. Springs 1374a, 1374b, normally urges the legs 1372a, 1372b, and thus the wall 1366 in the engagement direction 1376a. The springs 1378a, 1378b are sufficiently strong to securely maintain the trommel assembly 1338 in the engaged position (i.e., the position shown in Fig. 13) during normal operation, but permit the output portion 1309 to be moved in the disengagement direction 1376b manually (i.e., without the use of special tools, preferably without the use of any tools) in an amount sufficient to prevent disengagement and withdrawal of the trommel assembly 1338, e.g., for maintenance, cleaning, replacement, inspection, and the like. Preferably, a limit screw 1377a, 1377b provides a stop to prevent the force of the springs 1378a, 1378b from causing the bearing 1360 to thrust against the end cap 1318, undesirably increasing friction. In the depicted embodiment, the tray 1382 is formed in two portions 1383a, 1383b, coupled in a sliding fashion to permit the tray to be collapsed 1385. Collapsing the tray is believed useful in assisting in tray removal, for certain configurations, e.g., where space is restricted. Preferably the tray 1382 has sufficient capacity that tray emptying is required no more often than about once every two weeks, during normal anticipated use. Other fashions of permitting disengagement or movement of the bearing ring 1360 can be used, such as providing for hinged or pivoting movement. The depicted sliding movement is believed to permit removal of the trommel 1338, e.g., through the open bottom 1382 of the frame, while reducing or minimizing longitudinal space requirements. In the depicted embodiment, and output chute 1374 is provided adjacent the output opening of the trommel. In the depicted configuration the output chute 1374 is configured to direct coins, output from the trommel, in a substantially downward direction 1320. A tapered region 1378 assists in directing the coins.

Preferably, a tray or other container 1382 is located beneath the trommel assembly 1338 to catch dirt which passes through the trommel dirt openings. Preferably, the tray 1382 is configured to be easily removed (e.g., for emptying, cleaning, and/or permitting access to the underportion of the device). In the depicted embodiment, the first edge 1384 of the tray 1382 engages a rail or lip 1382 formed on the frame 1368, and the opposite edge 1386 may be ~~rotated upward to engage with spring clips 1390a, 1390b on the opposite side of the frame~~.

In one embodiment, a long object trap 2000 (Fig. 20) may be positioned between the input tray 1402 and the trommel 1306 to assist in preventing insertion of long, relatively rigid objects such as a popsicle stick, into the trommel. In the depicted embodiment, the long object trap includes a first, upstanding wall 2002 and, somewhat downstream, a

10

second, descending wall 2004. As depicted in Fig. 21, any attempt to insert a rigid elongated object 2006 will result in the object contacting a floor region 2008, preventing further passage.

C6 In operation, the user of the embodiment of Figs. 13 - 21 places a mass of coins, preferably all at once (typically accompanied by dirt or other non-coin objects) in the input tray 1402. The user is prompted to push a button to inform the machine that the user wishes to have coins discriminated. Thereupon, the computer causes the input gate 1324 to open (via solenoid 1326) and illuminates a signal to prompt the user to begin feeding coins. When the gate 1324 is open, the motor 1352 is activated to begin rotating the trommel assembly 1338. The user moves coins over the peak defined by the hinge 1414, typically by lifting the tray 1402 at least partially, and/or manually feeding coins over the peak 1414. The coins pass the gate 1396 (typically set to prevent passage of more than a predetermined number of stacked coins, such as by defining an opening equal to about 3.5 times a typical coin thickness). The coins move down the first trough 1310, where the pins 1322 prevent passage of certain long objects such as lottery tickets and the like. A long object trap (if any) prevents passage of other types of objects such as popsicle sticks. Coins continue to flow down the second trough or chute 1312. Coins travel through the chute collar mouth 1334 and into the interior of the rotating trommel assembly 1338. Within the rotating assembly 1338 the coins are lifted and free-fall, at least partially, through the interior of the trommel, preferably at least partially in response to provision of flat surfaces, corners, and/or vanes within the trommel. As the coins free-fall or are otherwise agitated by the rotating trommel, dirt particles or other non-coin objects pass through the holes of the trommel and fall into the tray 1382. Coins travel through the trommel, e.g., in response to angled disposition of the vanes and the inclination of the trommel, if any. In general is it believed that a larger angle provides for shorter residence time, but less thorough cleaning or lifting of the coins. Thus the angle selection may require a compromise between the desire for thorough cleaning and the desire for short residence time (which contributes to higher throughput). The depicted configuration, when the trommel rotates at about 36 RPM, and using a typical mixture of U.S. coins, provides a coin residence time of approximately 10 seconds. Under these conditions, throughput during normal use is believed to be sustainable at about 600 coins per minute or more. Configuration and operating conditions can be adjusted to increase or decrease throughput, e.g., by changing the size, length or capacity of the trommel, increasing rotation rate, changing vane configuration or angles, and the like, within structural constraints for desired durability, lifetime and maintenance costs. The coins, after being at least partially cleaned, exit the second opening 1364 of the trommel, and are directed by the output chute 1374 in an output direction 1320 toward downstream components such as the hopper of a coin transport/discrimination device.

Preferably, operation of the device is monitored, such as by monitoring current draw for the motor 1352. In this configuration, a sudden increase or spike in current draw may be considered indicative of an undesirable load and/or jam of the trommel assembly 1368. The system may be configured in various ways to respond to such a sensed jam such as by turning off the motor 1352 to stop attempted trommel rotation and/or reversing the motor, or altering motor direction periodically, to attempt to clear the jam. Jamming or undesirable load can also be sensed by other devices such

as magnetic, optical or mechanical sensors. In one embodiment, when a jam or undesirable load is sensed, coin feed is stopped or discouraged, e.g., by closing gate 1324 and/or illuminating a "stop feed" indicator 1328b.

Turning, now, to the embodiments of Figs. 3 - 12, in Fig. 3, the perforated tray 1402 provides a device for moving coins therein (upon lifting the tray 1402 about pivot axis 1414) through a slot 312, past a gate 314 which may be, e.g., a controllable gate, and via chute 316 into a perforated-wall cylinder 318. Preferably, the perforated wall cylinder 318 is configured to assist in or cause the relative movement of coins introduced thereto, such as by being rotatable in a first direction 322 about its longitudinal axis 324. Various rates of rotation can be used. Preferably, a high feed rate through the cylinder is achieved, such as a rate of at least 100 coins per minute, preferably at least 200 coins a minutes, more preferably at least about 600 coins per minute or more.

Preferably, the perforations or holes 326 formed in the surface or wall of the cylinder 318 are shaped or sized to prevent or avoid passage, through the holes 326, of the smallest coins which are intended to be counted by the counting device. Various hole or opening sizes and shapes are possible, giving due consideration to the size or diameter of the coins and, in some cases, the tumbling speed or rotational velocity. In one embodiment, oblong openings are provided and are believed to be useful, in some embodiments, in further assisting removal of non-coin matter.

Preferably, openings 318 are as large as possible to accommodate large non-coin matter without undesirably diverting or hindering the feed rate of smaller diameter coins. A number of factors may affect the choice of hole sizes. As described below, internal vanes, fins, ridges and other projections may be positioned, e.g., on the inside surface of the cylinder, and there must be sufficient remaining surface to allow these projections to be attached and/or formed. The size of the holes and/or the spacing and/or pattern of the holes may affect the strength or load capacity of the cylinder 318. Removing non-coin debris is important, and having a large amount of open surface area (total surface area of all holes in the cylinder 318) tends to increase the effectiveness of eliminating large objects, including large, dense and/or odd-shaped objects. However, the total area occupied by holes in the drum, while being desirably as large as feasible, should not be so large as to cause the cylinder to lose structural integrity, have a smaller than desired load capacity, and/or be subject to unwanted deflection or failure.

A number of different materials can be used for forming a cylinder 318. In one embodiment, the cylinder may be formed of cast urethane. In one embodiment, longitudinal steel and/or stainless tubing is used for the tumbler cylinder 318. Preferably, the tube is non-magnetic, such as being formed of stainless steel such as T-304, T-316, and/or ELC grade steel. By providing a non-magnetic tumbler, cylinder 318, avoids interfering with devices such as magnets (not shown) that may be provided for eliminating ferrous coins and/or ferrous non-coin matter. The thickness of the drum 318 can be selected to provide a desired coin capacity or load-bearing ability, a desired usable lifetime and/or desired wear factor. In one embodiment the cylinder 318 is constructed from corrugated spiral lock seam tubing. This embodiment is particularly useful in that blades or fins can be configured to be positioned adjacent to the spiral seams, which is believed to offer enhanced strength and/or higher pressure differentials, and thus allow a reduction in wall

thickness and overall mass of the cylinder over what would otherwise be required. A suitable tubing may be obtained from Perforated Tubes Incorporated of Ada, Michigan.

Preferably, one or more protrusions are provided extending inwardly into the interior of the cylinder 318. As depicted in Fig. 4, a helical blade 402 may be provided. The blade assists in moving the coins such as by lifting coins from a lower position to a higher position, and releasing the lifted coin on the upper level of the coins in cylinder 318, as the cylinder 318 is rotated 322. Further, in the depicted embodiment, the blade, being helical-shaped 402, acts to convey the coins in a direction 332 toward later or downstream apparatus such as a hopper 334. In this fashion, even though in the embodiment of Fig. 3 the axis 324 of the cylinder 318 is horizontal, coins may be moved in a direction 332, without the need for relying on a gravity feed. Such a configuration is useful in order to minimize the vertical extent 336 required for the device. If desired, however, the tumbler cylinder 318 may be tilted, e.g. as in Fig. 5, and, if desired, a gravity feed may be used to assist in moving coins.

Various materials may be used for forming or coating the interior surface and/or projections 402 of cylinder 318. A low friction or non-stick material such as Teflon may be used to avoid unwanted adhesion of coins or non-coin matter to the tumbler 318. In one embodiment, the surfaces that will come in contact with the coins and non-coin matter will be chemically resistant and inert, to avoid corrosion and/or reaction with materials that may be introduced into the tumbler 318. In one embodiment, the surfaces are durable since they will be constantly impacted by the coins and other materials. Wear-resistant materials that may be used include silicon carbide, or other ceramic material, steel, carbon-impregnated or carbon fiber or fiber-impregnated metals or ceramics or carbon impregnated foam, titanium, aluminum or other metals, nylon, polyvinyl chloride or other plastics or resins, and the like. In one embodiment the tumbler 318 is provided with materials for adsorbing, absorbing trapping or dissipating moisture, oils, finely divided particles, and the like. In one embodiment fins, blades or surfaces of the tumbler 318 are designed to abrade away over time, and are formulated to include materials which may assist in conditioning, cleaning, polishing, or otherwise conditioning the coins. For example, dry silicon lubricants may be included in the formulation, or abrasives for assisting or polishing coins. In one embodiment the fins, blades or other projections are removable so that they can be replaced or changed in shape or materials, as desired, to improve mechanical action, abrasion, polishing or other characteristics, or if replacement is required because of wear. Even if the projections or surfaces of the tumbler do not impart an abrasive material, it is believed that some abrasive or polishing action of the coins against each other will be achieved. It is believed that a material that self-destructs or disintegrates over time not only indicates wear, but also can be used for imparting cleaning abrader to not only help clean the coins, but eventually clean transport mechanisms, hoppers, sensors, sorting and counting mechanisms and other mechanisms throughout the machinery.

A number of devices for accommodating rotation of the tumbler 318 can be used. The tumbler assembly may be supported by a pillow block 702 (Fig. 9), a roller-supported 704a, 704b, 704c end cap 706, or may be provided with rollers or roller bearings 502a, 502b, 502c, or a bracket engaging a race or annular recess 504, or other bearing surface 708. If desired, one or more rollers 502a may be pivotable or spring loaded 524, e.g., to accommodate installation or

removal of the cylinder 318, e.g., for maintenance, repair, inspection, and the like. It is particularly desirable that the tumbler be configured for ease of removal so that it can be easily cleaned or replaced or jams may be cleared.

A number of devices may be provided for driving the rotationally-mounted cylinder. The cylinder may be coupled to a toothed pulley or gear 710. The toothed pulley or gear 710 may be driven via a gear train or a toothed belt, such as a timing belt, coupled to a motor, such as an alternating current or DC gear motor. In the embodiment of Fig. 9, an alternating current gear motor 802 has a shaft that connects to a pulley 804 for driving a toothed belt 806, which engages a pulley such as a toothed pulley 808, coaxial with the perforated cylinder 810. Suitable belts, motors or pulleys can be obtained, e.g. from SDT components company.

In one embodiment, materials which move through the perforations 326, are received in a tray or other receiving area, preferably one which may be easily removed for emptying and/or cleaning 338. Although in the embodiment depicted in Fig. 3 the tray 338 receives materials expelled from only the tumbler 318, and a separate tray 343 receives materials which moves through the perforations of the tilting tray 1402, if desired, a single tray or other receptacle can be provided for both purposes.

Preferably, the tumbler 318 or tumbler assembly is grounded appropriately to avoid static electric charge buildup, which could have the adverse effect of attracting certain non-coin materials to the drum. Conductive or non-static coatings or components may be used in constructing the drum 318. Preferably all materials along the coin path and tumbler are conductive and grounded. In one embodiment, a multi-fingered conductive charge gatherer, similar to a Christmas garland, may be used to collect and/or dissipate static.

In one embodiment, the apparatus is configured to provide a flow of air or other fluid past the contents of the tumbler to assist in removing lighter and low-density non-coin material. Air flow devices may include a positive pressure device, a negative pressure or vacuum device, or both, although it is believed that a vacuum system may, in some environments, create an undesirable amount of noise. Preferably, in the case of a vacuum, a filter or filter bag is provided for capturing materials. Positive pressure air may be configured to pass through a filter on the feed end 342 of the tumbler chamber. In one embodiment, cleansed air is flushed through the system and additional air flow is used to dissipate moisture and heat. A suitable filtering system may be obtained from Nikro Industries, Villa Park, Illinois 60181. In one embodiment, a filter is used conforming to specifications: 88 inches of water lift, 95 cubic feet per minute, 1.25 horsepower, meeting MIL-F-51079 and MIL-F-51068B. An example is model number DC00288.

In one embodiment a low back-pressure air transfer system may be used. In this system, a fan is mounted adjacent the coin-exit end of the tumbler 344, and a suction hose is positioned adjacent the coin-input end 342. The intake end of the suction hose may be screened or filtered to avoid damage to fans or other devices that power of the suction. Preferably there is little back pressure in the system and a relatively large amount of air is moved through as the coins are tumbled. In one embodiment the perforated cylinder 326 is enveloped and sealed with a housing to assist in directing air flow in the desired counter-current direction 334. The housing may be in the form of a semi-cylinder

covering which seals with a waste removal tray 338. Such a housing preferably also is useful in diminishing or deadening the noise of the tumbler device.

In one embodiment the system is substantially modular such as being contained, along with a feed tray 1402, in a rectangular or other modular housing 312. Preferably the modular design is configured to accommodate retrofitting in devices which do not currently have a tumbler. For example, a device such as that depicted in Fig. 1 may be retrofitted by removing the rectangular housing depicted in Fig. 2 and replacing with the rectangular modular unit of Figs. 8 through 11. In one embodiment the tubular tumbler is formed from two semi-cylindrical mating polyurethane components.

The present invention includes a number of features and embodiments. According to one embodiment, the invention includes a coin agitator for use in separating non-coin matter from coins for use in a coin counting device prior to transfer of said coins to a sensor mechanism of said coin counting device including a container with at least a first opening. In this embodiment, the coin agitator may include a tube. The tube may be movable by being rotatable substantially about its longitudinal axis. The tube may be perforated. A perforated tube may have a largest perforation size configured to prevent passage of a smallest desired coin. A plurality of projections may extend inwardly from a surface of said coin agitator. The agitator may include at least a first helical vane. The agitator may include at least a first fan configured for producing air flow through said coin agitator.

According to one embodiment, a coin conditioning apparatus for use in a coin discriminating may include a device for receiving a plurality of coins in a first region and for tumbling said received coins to assist in separating non-coin material; and a device for moving said coins through said receiving device. The apparatus may include a device for causing a fluid to flow through said receiving means during said tumbling. The apparatus may include a device for imparting a coin conditioning material into said plurality of coins. In one embodiment, said coin conditioning material is selected from the group consisting of a lubricant and an abrasive. In one embodiment, said coin conditioner is substantially modular to accommodate retrofitting. The apparatus may include a device configured to direct air flow in a direction counter-current to at least a first direction of coin movement. The apparatus may include a housing encompassing said coin conditioning device for reducing perceivable noise. The apparatus may include a positive pressure device for causing air flow through said coin conditioner. The apparatus may include a vacuum device for providing air flow through said coin conditioning.

In one embodiment, the invention provides a method for cleaning coins including:

introducing said coins into a rotatably mounted tube having sidewall perforations;

rotating said tube about its longitudinal axis to dislodge non-coin material;

moving coins in a first longitudinal direction through said rotating tube; and

flowing air through said rotating tube.

In light of the above description, a number of advantages of the present invention can be seen. The embodiment of Figs. 13 through 21 is believed to particularly provide for thorough and efficient cleaning of coins while

16

maintaining relatively high throughput, relatively low noise, and providing for ease of maintenance, replacement, inspection, and/or cleaning. This embodiment is useful in avoiding adhesion or slowing of coins along the depicted coin path by reducing or minimizing the potential for surface-to-surface contact of a coin with surfaces of the device. The device is relatively inexpensive to design, fabricate, construct, install and/or maintain, with many of the components being configured so that they may be formed by standard plastics or sheet metal fabrication processes such as stamping, drilling, injection molding and the like. Preferably the device is constructed with a shape, dimension and "footprint" that is compatible with earlier or in-service devices to permit ease of upgrading existing in-service devices, or ease of converting production facilities from production of existing devices, to production of devices according to the present invention.

The present invention provides an economical system and method for delivering clean coins to improve accuracy, durability and reliability of systems that identify, count, sort, discriminate and/or process coins and reducing jamming in input feed, transport and/or hopper devices. This system provides a system and method for self cleaning of a self-service coin processing device. The invention drives a tumbling mechanical agitation system for removing non-coin debris. The system reduces or eliminates the need for special services such as continually stopping a coin-counting device in order to perform maintenance of the identification, counting, sorting or transport components. The system preferably provides for wear indicating components such as wear indicating inner fins or other projections inside a tumbler. Preferably, the projections or other tumbler components are capable of imparting lubricants and/or abrasives or abrasive compounds. Preferably, the system provides a liquid or moisture removal system within the tumbler for removal of excess moisture or liquids, oils and the like, e.g., through an absorbent, adsorbent or desiccant component or feature of the tumbler fins or surfaces. In one embodiment, components are provided for dislodging or removing trapped items such as a floating or loose insert for dislodging items (such as a ball or other item which is too large to exit the exit hole) and/or finger rakes for dislodging trapped and/or dropped items.

A number of variations and modifications of the invention can be used. Although the invention is principally described as being useful in connection with cleaning coins, some or all features of the present invention can be used in connection with cleaning other types of devices such as regularly shaped items (e.g., golf balls), irregularly shaped items (such as screws, nuts, bolts, nails, and the like), and similar manufactured items. Although in one embodiment the device is controlled by a computer, other control devices can be used such as non-programmable or hard-wired control devices, application specific integrated circuits (ASICS), and the like. Although, in the above, items which are retained within the walls of the trommel are described as the objects to be cleaned and material passing through the holes in the walls of the trommel are described as "dirt," the device can be used in the opposite fashion, i.e. to recover relatively small valuable objects that pass through the holes of the trommel walls and discarding the large objects retained within the walls of the trommel. Similarly, the device can be used to separate large objects from small objects, neither of which is to be discarded.

In the above description, a number of surfaces (such as the chute surfaces and trommel interior surfaces) are provided with features which are believed to assist in avoiding the slowing or stopping of coin movement or flow (such as may result from friction, adhesion, surface tension or the like). These features may include dimples, surface curvature, ridges, holes and the like, and are believed to operate by reducing or eliminating surface-to-surface contact between a coin face and a surface of the apparatus. In general, any or all of these features may be used on any or all of the apparatus surfaces that are coin-contact surfaces, such that, for example the first and/or second chutes may be provided with dimples or ridges (with or without the curvature described above), or the trommel interior surface may be provided with a degree of curvature (with or without the dimples described above.)

In addition to, or in place of, moving coins by providing a rotatable cylinder, other types of movement of the tubular or concave surface may also be used for moving or agitating the coins, such as a rocking or tilting motion, a swinging motion, a vibrating motion, and the like. Although, in one embodiment, a circular cross-section tumbler is depicted, other shapes may be used in this embodiment such as triangular, square, pentagonal, hexagonal, octagonal, or other polygonal cross-section tubing, conical or parabolic-sided or other tapering or flaring tubing and the like. In one embodiment it would be possible to provide a separation device which is U-shaped and, rather than being rotated 322, is driven to swing through an arc or tilt in order to agitate the coins. While it is preferred to provide perforations in the tube of the concave surface, it is also possible to provide an embodiment in which a tube or concave surface is unperforated, and air flow is used for removing materials dislodged during tumbling, e.g., when only lightweight or low-density contaminants are anticipated. If desired, the vanes, fins or other agitating/moving devices may be separate from or movable with respect to the tubular or concave surface. It is possible to rotate or otherwise move the fins relative to either a fixed or rotating tube, including rotating the tube and fins in opposite directions. If desired, the tubular or concave surface and/or the projections may be coated with or may incorporate substances or surfaces to assist in cleaning, polishing or otherwise conditioning the coins, such as absorbent or adsorbent materials for removing liquids, oils, finely divided particles, and the like, or materials for transferring lubricants, abrasives, polishing compounds, and the like, to the coins. The tubular or concave surface or projections may incorporate or provide materials for reducing friction, avoiding static electric charges, avoiding corrosion, and the like. The tumbler and/or housing may be made from or may include anechoic, sound-deadening and/or anti-static material. The drum, internal vanes, etc. can be connected to a transmission and/or speed reducer that is computer controlled, e.g. to adjust tumbling speed based on sensed temperature, humidity, load weight, and/or in-feed or out-feed rate, or to suspend out-feed, e.g. in response to a sensed jam or other malfunction. If desired, a flow of air or other gases or, if desired, liquids, aerosols, mists, gels, and the like, may be introduced, preferably in a counter-current fashion with respect to the coin flow, to assist in conditioning the coins, e.g. by removing non-coin objects, especially small or lightweight non-coin matter such as hair and dust. A pressurized air and/or vacuum system may be used for causing such flow. If desired, filters may be provided for trapping some removed materials. In one embodiment, a cylindrical body having vanes rising from the inner diameter

17

and a plurality of openings is used. If desired, it would be possible to construct a device in which the perforated surface is maintained stationary, and a separate screw drive or other drive agitates and moves the coins to or across the stationary surface.

Although the invention has been defined by way of a preferred embodiment and certain variation modifications, other variations and modifications can also be used.